Method for Rapid/Early Detection of Internal Bleeding by Analysis of Laser Spectroscopy-Indicated Adrenaline Levels

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Introduction

A desire for improved methods for early detection of battlefield injuries that is both automated and low-cost has been expressed. It has been assessed that there is room for improvement, naturally, in battlefield triage procedures that could, if addressed, mitigate the fatality rate for battlefield injuries.

Abstract

Although advanced equipment is often available in-theater, limited resources dictate that individuals suffering from internal bleeding be identified accurately and early. Internal bleeding accounts for a high percentage of preventable fatalities where battlefield conditions and limited resources preclude the possibility of testing each and every soldier affected by an explosion, for example, for internal bleeding as one would routinely do when applicable in civilian hospitals. An accurate and affordable mechanism for detecting internal bleeding would enable us to increase the effectiveness of battlefield triage.

LASER light can be used to spectroscopically identify nearly any chemical compound. Ordinarily, this technology is used to measure concentrations of potentially hazardous gasses in the air, but it can easily be adapted to serve the same function in aqueous environments including within the human body. Along these lines, we already use IR absorptiometry to measure blood oxygen levels using affordable devices that clip to a patient's finger. These devices produce results in seconds and can provide ongoing, real-time data concerning blood oxygen levels.

I propose that a device with a similar form-factor can be similarly clipped to a patient's finger to fulfill the function of measuring relative levels of adrenaline over time in the first couple of hours after a traumatic injury.

Adrenaline, like any other compound, has a unique spectroscopic signature, absorbing some frequencies of light more than others. Rather than simply using spectroscopy to discern the mere presence of this hormone (obviously present in some small quantity in any person) a hyper-accurate measurement of the level of contrast of adrenaline's spectral lines could be used to non-invasively measure the adrenaline level in a section of a patient's finger.

When blood is being lost by the body gradually (as with internal bleeding,) blood pressure, thanks to natural mechanisms to maintain volemic homeostasis, remains constant and does not diminish except in end-stage hypovolemia. For most of the hours-long process of succumbing to internal bleeding, blood pressure remains constant until the very end, offering field medical personnel few clues to the hidden danger.

The primary mechanism the body employs to maintain this static ideal blood pressure is to secrete gradually increasing levels of adrenaline to constrict the blood vessels and maintain a stable pressure. While biologically the right thing to do, this compensation mechanism masks internal bleeding with respect to the use of blood pressure monitoring to identify the condition.

Rather than utilizing blood pressure monitoring for this purpose, I propose that that a LASER spectroscopy-based measurement of real-time adrenaline levels in parts per trillion can be used to diagnose internal bleeding accurately and in the early stages.

A soldier on the battlefield, for instance, would expect to have a rush of adrenaline immediately after sustaining an injury. Anything ranging from pain to anxiety could cause levels to spike, potentially making the cause of adrenaline fluctuations difficult to divine.

Once a soldier arrives in triage, morphine may be administered and more normative adrenaline level patterns can re-assert themselves. Even at this stage, some random fluctuations in adrenaline levels could be easily expected to be measured by this proposed detector.

To cut through the noise, a simple algorithm that looks at the moving average level of adrenaline over a short (10s,) medium (45s,) and long (5m) period could be used to determine which increases are caused by pain, which by anxiety, and which by blood loss, with the increases in adrenaline associated with blood loss being the most gradual of those three primary causes.

Any patient that has a long term upward trend in adrenaline after being at least mildly sedated (at least a 1pg/mL increase for each of four, 5-minute periods) would be red-flagged for probable internal bleeding and sent for further testing.

Conclusion

Although a clinically accurate measurement of adrenaline concentration would require calibration tailored to the individual, for this application, that level of calibration is unnecessary. All that is necessary here is that a relative baseline index value be established for a sedated, calm patient and that relative changes be discernible relative to the baseline value for that particular patient.